

Supplementary material to the article “Localization of distributed EEG sources in the context of epilepsy: a simulation study”

Hanna Becker, Laurent Albera, Pierre Comon, Rémi Gribonval, Fabrice Wendling, Isabelle Merlet

Results in terms of patch center distance

In the following, we report the performance results of the source imaging algorithms for the considered scenarios in terms of a third evaluation criterion, the Patch Center Distance (PCD). Contrary to the DLE and the ROC, which are designed to evaluate the reconstruction of patches by taking into account all dipoles of the original and estimated source configurations, the PCD measure considers only one point for each original or estimated source region. Thereby it does not put source imaging algorithms that are conceived for point-sources at a disadvantage, unlike the DLE and ROC.

S.1. PCD criterion

For the p -th original patch, the PCD is determined with respect to the center \mathbf{c}_p of the patch, which we define as the position of the dipole that is closest to the average position of all patch dipoles. For the estimated source configuration, in case of the algorithms sLORETA, cLORETA, MCE, MxNE, and Champagne, the reference position $\hat{\mathbf{c}}_p$ used for calculating the PCD of the p -th patch corresponds to the position of the dipole associated with the local peak, i.e., the position of the dipole that has the highest amplitude among all dipoles that are closer to the center of patch p than to the center of any other patch. For STWV-DA, 4-ExSo-MUSIC, and SVB-SCCD, the estimated patch centers are determined in the same way as for the original patches. Note however, that for SVB-SCCD, we average only the positions of the patch dipoles whose amplitude exceeds 99% of the maximum amplitude of the patch dipoles. Finally, the average PCD is computed as

$$\text{PCD} = \frac{1}{P} \sum_{p=1}^P \|\mathbf{c}_p - \hat{\mathbf{c}}_p\|_2.$$

S.2. Results

S.2.1. Influence of the patch position

Table 1 lists the PCD results of the tested source imaging methods for the considered single patch scenarios. Here, STWV-DA and 4-ExSo-MUSIC achieve the best results in terms of PCD for all scenarios except for patches InfFr and Cing, where sLORETA outperforms all other methods. Furthermore, STWV-DA and 4-ExSo-MUSIC feature

good results for all scenarios whereas the results of the other methods vary depending on the scenario. The results of cLORETA are among the worst in most cases.

patch	InfFr	InfPa	Cing	SupOcc	PreC	BasTe	MidTe	Hipp
sLORETA	0.78	4.75	2.59	1.92	13.2	8.37	15.6	10.4
cLORETA	10.0	7.75	32.7	7.04	7.25	10.9	20.0	20.3
SVB-SCCD	4.17	4.75	25.6	0	1.30	7.88	7.10	20.4
MxNE	6.55	4.75	22.1	9.83	7.25	13.5	15.8	17.8
MCE	6.80	4.75	23.5	9.55	7.25	14.9	19.8	17.8
Champagne	14.6	4.07	4.94	8.48	10.3	9.12	7.93	11.0
STWV-DA	2.30	0.30	4.31	0	0	6.10	3.78	2.21
4-ExSo-MUSIC	2.30	0.18	4.32	0	0.06	6.11	3.78	1.71

Table 1: Performance of source imaging algorithms in terms of PCD (in mm) for the 8 different single patch scenarios. The smallest obtained PCD value for each patch is marked in bold.

S.2.2. Influence of the patch size

In Table 2, the PCD values of the different algorithms are shown as a function of the size of the patch SupFr. STWV-DA once again outperforms the other methods in terms of PCD, closely followed by 4-ExSo-MUSIC. The third best algorithm here is SVB-SCCD and the worst methods in terms of PCD are MCE and MxNE.

patch size	10 dipoles	100 dipoles	400 dipoles
sLORETA	7.92	9.21	12.14
cLORETA	8.58	6.08	9.67
SVB-SCCD	4.93	2.98	7.91
MxNE	16.3	11.0	26.7
MCE	14.8	11.0	26.7
Champagne	7.05	8.40	12.3
STWV-DA	0.52	0.52	0
4-ExSo-MUSIC	1.24	0.73	0

Table 2: Performance of source imaging algorithms in terms of PCD (in mm) depending on the size of the patch SupFr. The smallest obtained PCD value for each patch is marked in bold.

S.2.3. Influence of the patch number

For the multipatch scenarios, the obtained PCD values are displayed in Table 3. STWV-DA leads to the smallest PCD for the two considered two-patch scenarios, whereas SVB-SCCD outperforms all other methods for the considered three-patch scenarios.

S.3. Conclusion

On the whole, it can be said that according to the PCD, STWV-DA, 4-ExSo-MUSIC, and SVB-SCCD are the algorithms with the best source localization results for the considered scenarios, confirming the results obtained in terms of DLE and ROC. Despite

scenario	InfFr & InfPa	InfFr & MidTe	InfFr & InfPa & SupOcc	InfFr & MidTe & OccTe
sLORETA	3.36	8.93	7.37	11.2
cLORETA	8.90	14.8	10.2	12.7
SVB-SCCD	4.44	5.67	3.07	6.37
MxNE	5.76	10.9	7.12	9.82
MCE	5.76	11.0	8.10	9.82
Champagne	9.86	10.8	9.10	10.3
STWV-DA	1.13	3.18	3.52	9.90
4-ExSo-MUSIC	1.25	35.7	12.5	10.5

Table 3: Performance of source imaging algorithms in terms of PCD (in mm) for the considered scenarios with two and three patches. The smallest obtained PCD value for each scenario is marked in bold.

the fact that the PCD does not take into account the size of the original and estimated patches, but evaluates only their positions, the performance of the algorithms conceived for estimating focal sources, namely sLORETA, cLORETA, MCE, MxNE, and Champagne, is still worse than that of the algorithms designed for estimating distributed sources. This means that for the analyzed source configurations, the distributed source localization algorithms STWV-DA, 4-ExSo-MUSIC, and SVB-SCCD are not only superior for recovering the spatial extent of the patches, but also for estimating the patch positions.